NOTICE

All drawings located at the end of the document.

WORK PLAN

SOIL EROSION/SURFACE WATER SEDIMENT TRANSPORT MODELING FOR THE ACTINIDE MIGRATION STUDY AT THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

February 16, 1998

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PURPOSE

The purpose of this work plan is to provide a framework for conducting soil erosion and surface water sediment transport modeling for the Rocky Flats Environmental Technology Site (Site) in support of actinide transport modeling for the Actinide Migration Studies (AMS) The AMS is investigating the mobility of plutonium (Pu), americium (Am), and uranium (U) in the Site environment The goal of the AMS is to include the following, in the order of urgency

1 Urgent Determine the important Pu and Am migration sources and migration processes that account for recent surface water quality standard exceedances
2 Near Term Determine the impacts of actinide migration on planned remedial actions To what level do sources need to be cleaned up to protect surface waters from exceeding action levels for actinides?
3 Long Term Estimate how will actinide migration affect surface water quality and compliance after Site closure Determine if soil Action Levels will be sufficiently protective of surface water over the long term
4 Long Term Estimate long term off-site actinide migration, and its impact on downstream areas (e g accumulation)

These questions will be answered by determining what factors significantly affect actinide transport in media of concern, and mathematical modeling of those actinide transport processes identified as important contributors to actinides migration in the Site environment Current information suggests that actinide transport in sediments by overland flow (soil erosion), and in channeled surface water, is an important transport mechanism contributing to potential exceedances of surface water standards in both the short- and long term The most efficient method for assessing contributions of soils and sediments to surface water loads of actinides is through the use of models The current work is limited to consideration of transport in and by water, wind transport will be considered during FY99

SCOPE

The Water Erosion Prediction Project (WEPP) Hillslope Profile and Watershed Model will be used to estimate the quantities of sediments transported to, and by, surface water via environmental pathways, including

- Runoff / Diffuse Overland Flow, and
- Surface Water Flow (Channeled)

The WEPP Model will be used to estimate sediment loading to channels within the Walnut and Woman Creek Watersheds, and may be sufficient to estimate the downstream

movement of sediments within the channels If it is determined that the WEPP Model channel flow component does not have the necessary degree of resolution, the sediment loading results will be coupled with a yet to be determined surface water transport model (e g OTIS/OTEC) to estimate sediment movement within the watershed channels The amounts of Pu and Am associated with the sediments will be estimated based on data defining spatial distribution and detailing actinide associations with soil particle sizes and phases The results will be used to estimate the effects on surface water quality for the present Site configuration and for selected potential future configurations in order to address the four goals stated above Estimates of erosion and sediment movement within the watersheds will be made for periods of up to 1,000 years

The Model

The WEPP Watershed Erosion Model , developed by the United States Department of Agriculture (USDA) and the United States Department of the Interior and other cooperators, is a new generation of process-oriented, computer implemented erosion prediction technology, based on modern hydrologic and erosion science The WEPP model is a continuous simulation computer program which predicts, (1) soil loss and sediment deposition from overland flow on hillslopes, (2) soil loss and deposition from concentrated flow in small channels, and (3) sediment deposition in impoundments The model includes a stochastic weather generator (CLIGEN) to provide daily weather information using local meteorological data, a winter processes component, a hydrology component based on a modified Green-Ampt infiltration equation and solutions of the kinematic wave equations to estimate runoff, a daily water balance component, and a plant growth and residue decomposition component The model computes spatial and temporal distributions of soil loss and deposition It estimates when and where on a hillslope or watershed channel the erosion and deposition are occurring The channel component of the model is designed to estimate flow and sediment transport for ephemeral flow drainages with areas up to about 60 km^2

Study Area

Three drainage basins collect surface water at RFETS (Figure 1) The basins are drained by natural, intermittent ephemeral, and perennial streams that generally flow from west to east The northwest portion of the Site is drained by Rock Creek, which flows into Coal Creek east of the Site This drainage is not considered to have been affected by site activities and will not be included in this study Walnut Creek drains the northeast quadrant of the Site, and Woman Creek collects water from the southern portion of the buffer zone The study area includes these two watersheds, which are described below

The on-site portion of the Woman Creek Watershed is approximately 3 1 square miles (2,000 acres) Woman Creek is formed by two branches to the west, known as the northwest and southwest branches These branches converge to the west of the Original Landfill There are two detention ponds in the Woman Creek drainage (1) Pond C-1

which is located within the stream channel and is presently configured for continuous flow-through, (2) Pond C-2 which is off channel and used to collect runoff from the south side of the Industrial Area (IA), the 881 Hillside, and the 903 Pad Lip Area via the South Interceptor Ditch (SID) Pond C-2 is batch discharged to Woman Creek In the past, the majority of water from Woman Creek was diverted into Mower Ditch The diversion is currently shutoff and water flows in the natural channel off-site to the Woman Creek Reservoir

The Walnut Creek Watershed is about 3 7 square miles (2,300 acres) in area (Figure 1) The watershed is comprised of two perennial streams South Walnut Creek and North Walnut Creek, and ephemeral to intermittent features known as No Name Gulch and the McKay Bypass Canal

South Walnut Creek receives runoff from the IA, including the Central Avenue Ditch and the 903 Pad Area The natural channel has been greatly changed by construction in the IA and the B-Series Detention Ponds (Figure 1) Ponds B-1 and B-2 are normally off-line, but maintained at a level to keep sediments wet and for IA spill control Water in Pond B-3 is batch discharged to B-4 then flows through to B-5 which is currently pumped to Pond A-4 in North Walnut Creek A gate valve and stand pipe are being install in Pond B-5 that will allow direct batch releases in the near future

Water in the upper reaches of North Walnut Creek, to the northwest of the IA, is diverted to the McKay Bypass, flowing to the north of the Current Landfill and eventually re-entering the Walnut Creek drainage downstream of No Name Gulch Water draining from the north side of the IA, enters North Walnut Creek, and is diverted by pipeline around Ponds A-1 and A-2 into A-3 Ponds A-1 and A-2 are used for spill control and do not discharge into the drainage Pond A-3 is batch released to Pond A-4, which is batch discharged into the North Walnut Creek channel

The Current Landfill and the Landfill Pond are situated in the headwaters of No Name Gulch The Landfill Pond does not discharge into the gulch Flows in No Name Gulch result primarily from runoff from surrounding hillsides

The study area includes all areas drained by the Woman and Walnut Creek Watersheds The areas drained by each watershed will be split into sub-basins (hillsides) for modeling, based on topography and resultant drainage patterns, using Geographical Information Systems (GIS) watershed definition techniques The smaller-scale SID drainage (contained in the Woman Creek Watershed) will be used for initial calibration of the model Modeling efforts will then move to Walnut Creek to provide information to address recent exceedances of surface water standards and answer the urgent question as stated in the Purpose Section The Woman Creek Watershed will then be modeled, including the SID This will provide information to guide the selection of cleanup levels for the 903 Pad Area The study area is limited to the Site property, but estimates of actinide loading to off-site watershed reaches will be made in order to assess potential downstream impacts

Data Needs

Input data files necessary to run the WEPP Watershed Model are divided into two categories 1) files required for running the hillslope component, 2) files required to run the watershed simulation component

The hillslope component requires four input data file, with a fifth optional 1) a climate file, 2) a slope file, 3) a soil file, 4) a plant/management file, and 5) an optional run file, containing answers to model interactive questions The watershed simulation component requires a minimum of seven files 1) a hillslope information pass file (created by model program), 2) a structure file that contains information on the watershed configuration (created by model program), 3) a channel slope file with information on the channel characteristics, 4) a channel soil file, 5) a channel management file, 6) a channel climate file (identical to the hillslope climate file), 7) a watershed channel file (includes information necessary for hydraulic routing), and 8) an impoundment file (optional)

Model input data requirements, availability, and sources are summarized in Table 1 Radian Corporation will provide Site meteorological data in the format required by the model PTI Environmental Services will compile the necessary Site specific vegetation and cover data for the watersheds An extensive soil sampling program has been undertaken by RMRS Environmental Remediation Division for characterization of areas of the Walnut and Woman Creek Watersheds with little or no Pu and Am data (*Investigation of Surface Soil Actinide Content in the Walnut Creek and Woman Creek Watersheds at the Rocky Flats Environmental Technology Site, Sampling and Analysis Plan, February, 1998)* RMRS will gather and provide soil, watershed configuration, and actinide data, and provide GIS services to facilitate the development of the model and presentation of the results

Data Sources and Description

Data for this modeling effort will come from the following Site programs

- Meteorology Climatological Data,
- Ecology Vegetation and Cover Data,
- Surface Water Precipitation, Surface Water Flow/Discharge, Total Suspended Solids, and Actinide Activity Data,
- GIS Integration of Topographic, Vegetation, Soils, and Watershed Drainage Data,
- Past Operable Unit Characterizations and RI/RFI Reports Soils and Actinide Distribution Data, and
- Special Projects/Studies Particle Size Association of Actinides (in progress)

Table 1. WEPP model data input requirements.

Input File	Data Needs	Source	Availability
Climate File (Hillslope and Watershed Components)	Meteorology Data, Precipitation, Wind, Temperature, Dew Point	RFETS Records, Supplemented With Nearby Station Data, Meteorology Services	Available
Slope File	Overland Flow Elements[1] (OFE), Hillside Length, Width, Slope	RFETS Data AMS Modeling Team, GIS Services	To be Calculated by GIS Services
Soil File (One For Each OFE and Channel)	Soil Type, Texture, Porosity, Conductivity, OM, CEC, Albedo, Number and Depth of Soil Layers	RFETS Data, AMS Modeling Team, GIS Services	Available
Plant/Management File (one for each OFE and Channel)	Plant Types, Characteristics, Growth Parameters, Management Practices	RFETS Data, AMS Modeling Team, Ecology Support	Available
Watershed Structure File	Describes Watershed Configuration	AMS Modeling Team, GIS Services	Available
Watershed Channel File	Characteristics of Channel, Shape, Depth, Erodability, Hydraulic Parameters	Observations by AMS Modeling Team and RMRS Surface Water Group	Field Observations (See Drainage Master Plan)
Impoundment File	Characteristics of Impoundment and Outlets	Observations by AMS Modeling Team and RMRS Surface Water Group	Field Observations (Pond bathimetry available)

1 Overland Flow Elements are regions of homogeneous soils, cropping, and management on a hillslope Each hillslope may have as many as ten OFEs

Model Objectives

The erosion modeling effort has multiple objectives directly related to the four AMS goals

- Provide information for determining if diffuse, low level sources of Am and Pu in the Walnut Creek Watershed have contributed to recent exceedances of the 0 15 piC/L surface water standard,
- Estimate the long-term movement of Am and Pu in surface waters originating in the Walnut Creek and Woman Creek Watersheds, and to what extent diffuse, low-level sources may contribute to potential future exceedances of the 0 15 pCi/L surface water standards,
- Provide information to aid in the determination of cleanup levels for the 903 Pad Area that will be protective of surface water by estimating short and long-term actinide loading to the Woman Creek Drainage from the 903 Hillside Area, and
- Investigate the effects of potential changes in site configuration and long-term climate patterns on the movement of actinides associated with sediments to surface waters and potential transport off-site

Model Output

The output of the WEPP model includes generated weather patterns for selected time spans, estimates of runoff volumes and erosion/deposition for 100 points per hillslope, sediment delivery to drainages, including particle size breakdown, organic mater, and surface area enrichment, and the volume of channel flow and sediment movement out of the watershed

The output of the model is in a report format Programs will be written to strip out the data and place it in a erosion/sediment database The information in the database will then be used for reporting, statistical applications, and GIS manipulations for visual presentation of the results The model output will be combined with existing Pu and Am surface soil data and the results of the current watershed soil sampling effort The data collected will also include the association of Pu and Am with particle sizes in the surface soils that can be related to particle size estimates for sediments from the model

Calibration of Model Output

Model output will be calibrated with existing surface water data The initial study area will be the SID drainage The SID was chosen because it is a relatively simpler system than the Walnut Creek or Woman Creek Watersheds Historical precipitation events will

be chosen for which reliable surface water monitoring data exists Estimated sediment transport from the WEPP model will be compared to the empirical data Refinements to the model inputs will be made based on the results of the comparison Uncertainty will be estimated by comparing the estimated and empirical data. The sediment data will then be coupled with Pu and Am activity-concentrations on the hillslopes to estimate amounts associated with the transported sediments The radiological error terms will be incorporated into overall uncertainty estimates Results will be compared to actual surface water Pu and Am data The estimation technique will be refined as necessary to reflect the empirical data It is envisioned that this will be an iterative process and may take considerable effort to relate Pu and Am activity-concentrations on particular areas of a hillside to sediments leaving the bottom of the hillslope The method used by the model to report erosion and deposition down the length of the hillslope should enable this process

Sensitivity Analysis

A sensitivity analysis has previously been performed for some WEPP model input parameters (Nearing et al , *USDA-Water Erosion Prediction Project Hillslope Profile Model Documentation,* NSERL Report no 2, USDA-ARS National Soil Erosion Prediction Laboratory, August 1989) Data uncertainties will be compared to known model sensitivities to establish confidence estimates for modeling output

If it is determined to be necessary, a sensitivity parameter, S, will be calculated for chosen model inputs using the following equation

$$S = \frac{\left\{\frac{O_2 - O_1}{O_{\bar{1}\bar{2}}}\right\}}{\left\{\frac{I_2 - I_1}{I_{\bar{1}\bar{2}}}\right\}}$$

where I_1 and I_2 are the least and greatest values of input use, respectively, $I_{\bar{1}\bar{2}}$ is the average of I_1 and I_2, O_1 and O_2 are the associated outputs for the two input values, and $O_{\bar{1}\bar{2}}$ is the average of the two outputs S represents the relative normalized change in output, and provides a valid means of comparing sensitivities for parameters that have different orders of magnitude

Schedule

The schedule for the Watershed Modeling Project for FY98 is shown in Figure 2 The model will be calibrated on the SID drainage due to the relatively simple configuration The Walnut Creek Watershed will be modeled next in order to address the urgent question of the source of surface water exceedances in this drainage It is anticipated that

this phase of the modeling effort will be completed in July, 1998 A progress report will be produced for this phase, reviewed and finalized by September 30, 1998 The remainder of the watershed modeling will be completed in FY99, including the Woman Creek drainage and long-term modeling incorporating various future Site configuration scenarios A final report which will include all modeling results will be delivered by the end of FY99

Deliverables

Results of the FY98 modeling and analysis will be initially presented in a progress report at the end of FY98 A final report for both FY98 and FY99 results for each watershed will be published at the end of FY99 The final report will discuss the models used, data sources, modeling methodology, calibration results, modeling results, model sensitivities, data uncertainties and confidence, and implications for remediation goals, short and long-term surface water quality, and off-site transport of actinides

Figure 2 - Schedule for FY98 and FY99 Soil Erosion/Surface Water Sediment Transport Modeling

ID	Task Name	Duration	Start	Finish
1	**Soil Erosion/Surface Water Planning**	**53d**	**12/8/97**	**2/18/98**
2	WEPP Modeling Work Plan	50d	12/8/97	2/13/98
3	Mass Loading Work Plan	44d	12/8/97	2/5/98
4	Surface Soil Sampling Plan	25d	1/5/98	2/6/98
5	Surface Soil Sampling	4d	2/13/98	2/18/98
6	**FY98 Watershed Modeling**	**213d**	**12/8/97**	**9/30/98**
7	**WEPP Model Input Compilation**	**148d**	**12/8/97**	**7/1/98**
8	*Acquire CDPHE Soil/Grain-Size Data*	13d	12/8/97	12/24/97
9	Analyze Existing Grain-Size/Pu Soil Data	89d	2/27/98	7/1/98
10	New Activity Data - Soil, Sediments, TSS	66d	4/1/98	7/1/98
11	Surface Water Loading Analysis	15d	2/9/98	2/27/98
12	Build Modeling database	33d	2/16/98	4/1/98
13	**SID Drainage Model**	**98d**	**2/16/98**	**7/1/98**
14	WEPP Model Calibration on SID	35d	2/16/98	4/3/98
15	Relate estimated SID loading to actinide data	19d	4/2/98	4/28/98
16	Populate Database w/ SID Data	52d	3/2/98	5/12/98
17	Sensitivity/Uncertainty analysis	8d	4/29/98	5/8/98
18	Data Presentation	55d	4/16/98	7/1/98
19	**Walnut Creek Watershed Modeling**	**57d**	**5/11/98**	**7/28/98**
20	WEPP Model Calibration on Walnut Cr	35d	5/11/98	6/26/98
21	Relate est Walnut Cr loading to actinide data	20d	6/15/98	7/10/98
22	Populate Database w/ Walnut Cr Data	48d	5/11/98	7/15/98
23	Uncertainty analysis	8d	7/10/98	7/21/98
24	Data Presentation	20d	7/1/98	7/28/98

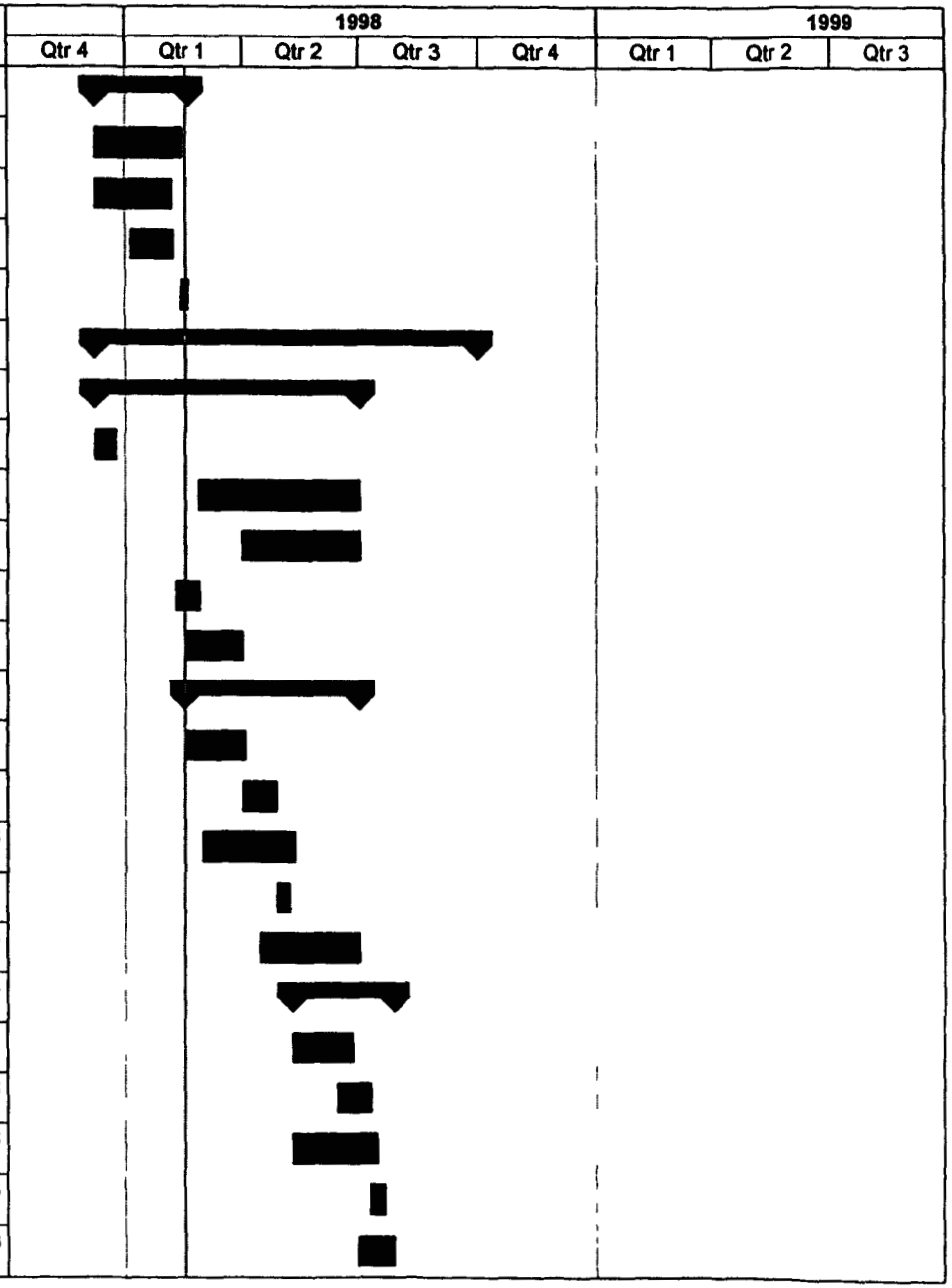

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Figure 2 - Schedule for FY98 and FY99 Soil Erosion/Surface Water Sediment Transport Modeling

ID	Task Name	Duration	Start	Finish
25	**Surface Water Model (?)**	**105d**	**2/16/98**	**7/10/98**
26	Surface Water Model Evaluation	24d	2/16/98	3/19/98
27	Surface Water Model Calibration on SID	21d	3/19/98	4/16/98
28	Surface Water Model Calibration on Walnut Cr	25d	5/11/98	6/12/98
29	Populate Database w/ Walnut Cr Data	67d	3/19/98	6/19/98
30	Compile Surface Water Model Results	16d	6/19/98	7/10/98
31	**FY98 Progress Report**	**66d**	**7/1/98**	**9/30/98**
32	Compile FY98 Results	11d	7/1/98	7/15/98
33	GIS Support	39d	7/1/98	8/24/98
34	1998 Draft Progress Report	43d	7/1/98	8/28/98
35	Review and Comment on Draft	10d	9/1/98	9/14/98
36	Final Progress Report on Erosion	13d	9/14/98	9/30/98
37	**FY99 Watershed Modeling**	**254d**	**10/1/98**	**9/20/99**
38	**Woman Cr Modeling**	**109d**	**10/1/98**	**3/1/99**
39	WEPP Model Calibration on Woman Cr	76d	10/1/98	1/14/99
40	Surface Water Model Calibration on Woman C	81d	10/1/98	1/21/99
41	Populate Database w/ Woman Cr Data	83d	10/7/98	1/29/99
42	Uncertainty analysis	12d	1/15/99	2/1/99
43	Data Presentation	21d	2/2/99	3/1/99
44	**Future Site Configuration Modeling**	**165d**	**2/3/99**	**9/20/99**
45	Future Site Modeling	64d	2/3/99	5/2/99
46	Populate Database w/ Future Site Data	65d	2/8/99	5/7/99
47	Uncertainty analysis	12d	5/3/99	5/18/99
48	Data Presentation	60d	5/3/99	7/23/99

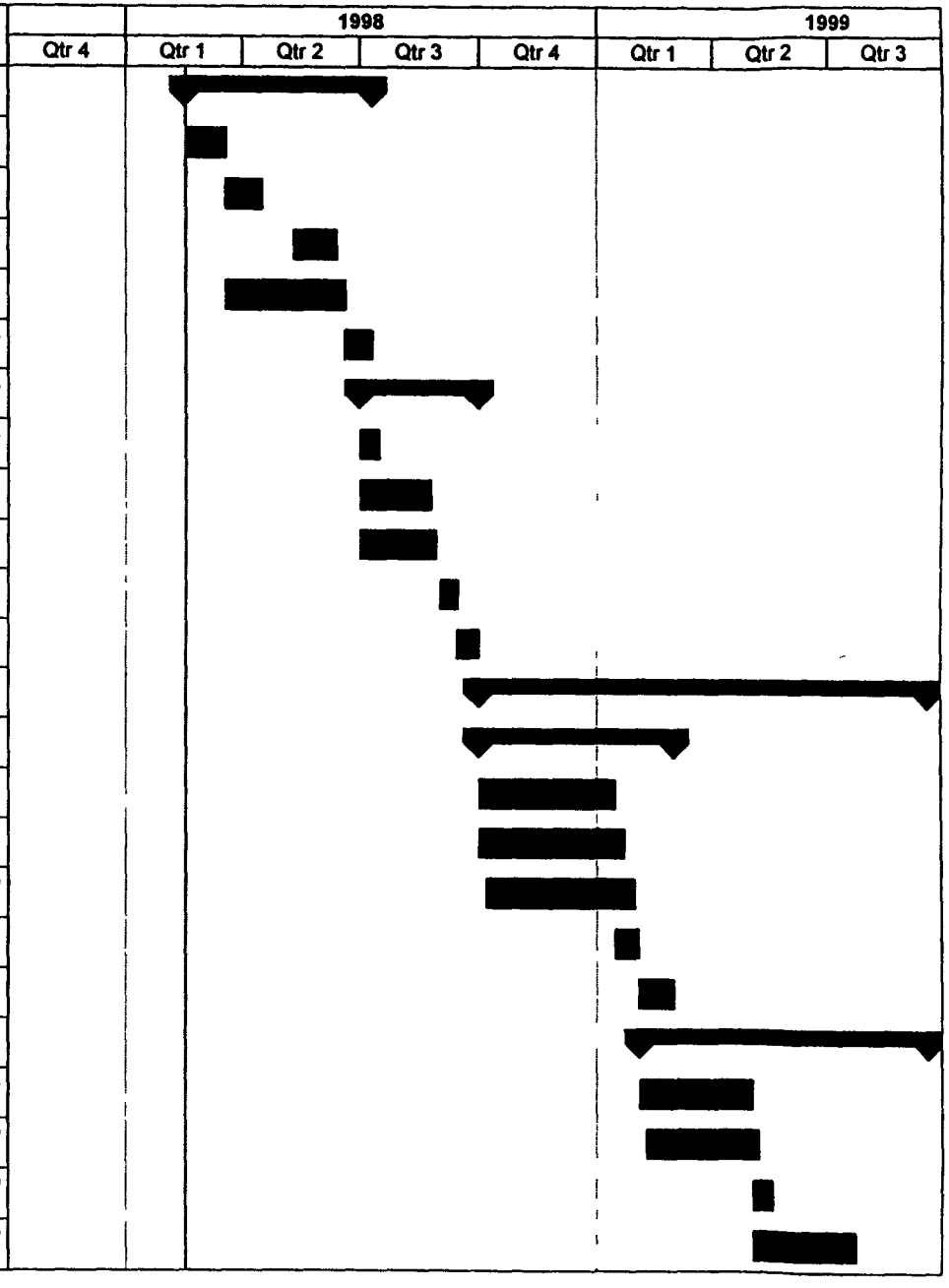

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Figure 2 - Schedule for FY98 and FY99 Soil Erosion/Surface Water Sediment Transport Modeling

ID	Task Name	Duration	Start	Finish	1998 Qtr 4	1998 Qtr 1	1998 Qtr 2	1998 Qtr 3	1998 Qtr 4	1999 Qtr 1	1999 Qtr 2	1999 Qtr 3
49	Write Draft Final Report	48d	5/19/99	7/25/99								
50	Review of Draft Final Report	15d	7/26/99	8/13/99								
51	Final Report Erosion/Surface Water Transport	27d	8/13/99	9/20/99								

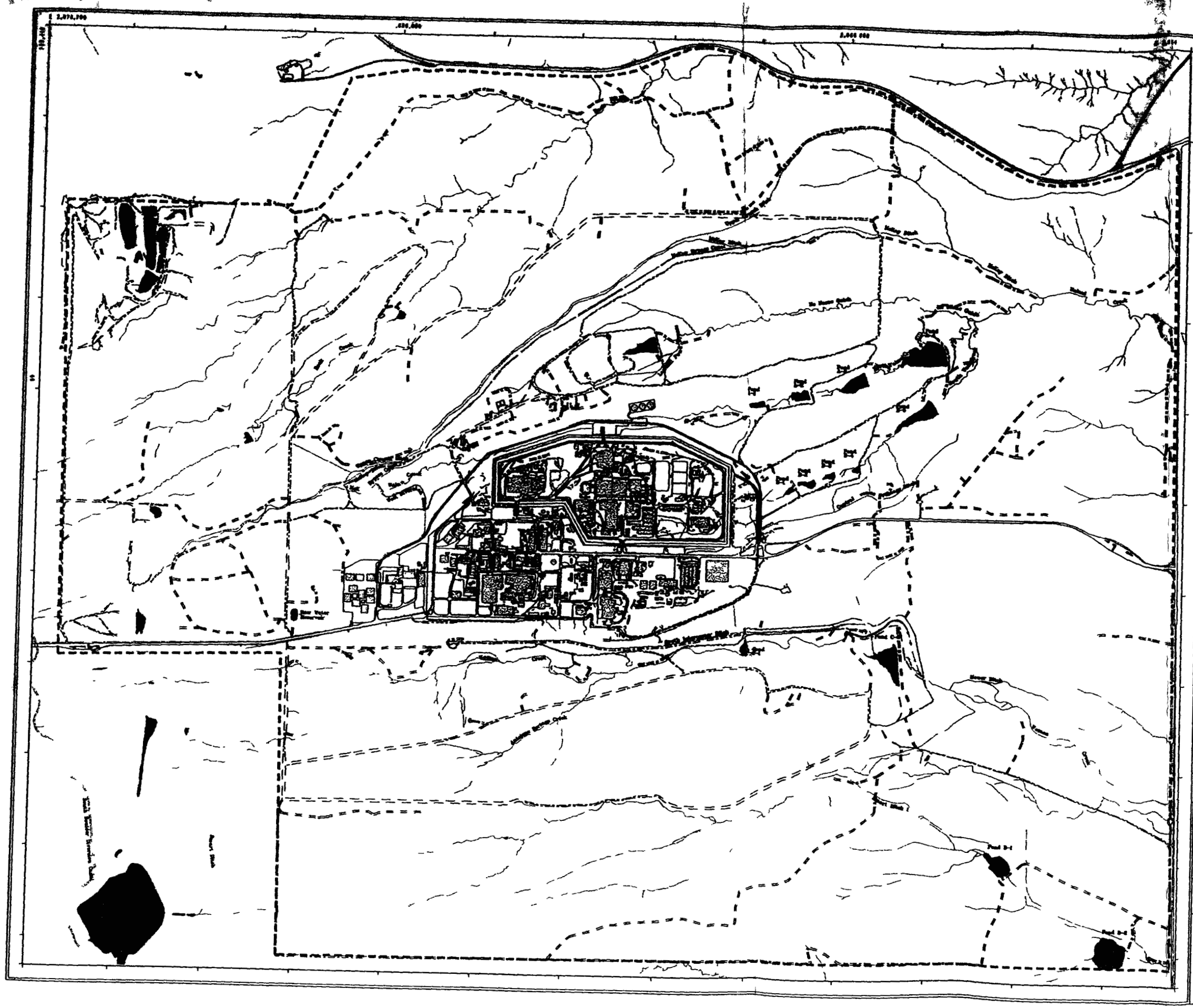

Figure 1

RFETS
Drainage Features

EXPLANATION

Standard Map Features

- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCES

Scale = 1 21330
1 inch represents approximately 1778 feet

600 0 1000 2000ft

State Plane Coordinat Projection
Colorado Cent al Zone
Datum NAD27

U S Department of Energy
Rocky Flats Environmental Technology Site

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MAP ID: 98-0087

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If this line is 7 in long the scale is